Radiation Shielding Materials Containing Hydrogen, Boron, and Nitrogen: Systematic Computational and Experimental Study

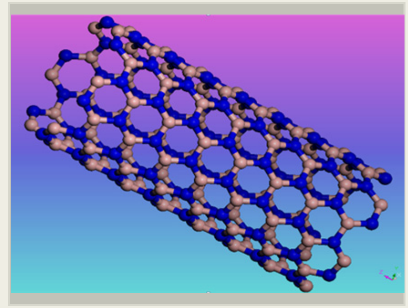
Completed Technology Project (2011 - 2012)

Project Introduction

The objectives of the proposed research are to develop a space radiation shielding material system that has high efficacy for shielding radiation and also has high strength for load bearing primary structures. The NASA Langley Research Center, Jefferson National Lab, and National Institute of Aerospace as joint owners have recently synthesized long, highly crystalline boron nitride nanotubes (BNNT) using a novel pressure/vapor condensation method. The BNNT have extraordinary strength and high temperature stability. The BNNT are made up entirely of low Z (atomic number) atoms - boron and nitrogen. The BNNT can theoretically be processed into structural BNNT and used for load bearing structure. The BNNT are nanotubes; their molecular structure is attractive for hydrogenation. A comprehensive literature search - as well as independent thinking - will be performed to determine what is the best processing approach for hydrogenating the BNNT. Neutrons are produced as secondary radiation when the galactic cosmic radiation and solar energetic particles interact with the walls of the space structure and also with the regolith on the surfaces of Moon or planets. This secondary neutron radiation has largely been ignored in previous space architectures and yet neutron radiation is known to be damaging to humans especially with regard to the formation of radiogenic cancers. Radiation protection is an enabling technology for future exploration missions. The Agency cannot support human missions greater than approximately 90 to 100 days beyond LEO without developing shielding and/or biological countermeasures to remain below Permissible Exposure Limits. The Success Criteria are adequate shielding measures to enable safety of crew and hardware during long duration human missions up to 1 year in space. It is the intent of the proposed research to bring the Agency closer to extending space missions beyond the 100 days, with 1 year as a long-term goal.

Anticipated Benefits

Potential Impact/Benefits: Radiation protection is an enabling technology for future exploration missions. The Agency cannot support human missions greater than approximately 90 to 100 days beyond LEO without developing shielding and/or biological countermeasures to remain below Permissible Exposure Limits. The Success Criteria are adequate shielding measures to enable safety of crew and hardware during long duration human missions up to 1 year in space. It is the intent of the proposed research to bring the Agency closer to extending space missions beyond the 100 days, with 1 year as a long term goal. Hydrogen, boron, and nitrogen based materials can provide mechanically strong, thermally stable, structural materials with effective radiation shielding against GCR, neutrons, and SEP. Preliminary neutron exposure tests at LaRC on BN containing polymers and BNNT containing polymers showed great promise for radiation shielding. Lightweight durable multifunctional materials in all forms are needed for radiation protection for both humans and microelectronic components. Electronic



Project Image Radiation Shielding Materials Containing Hydrogen, Boron, and Nitrogen: Systematic Computational and Experimental Study

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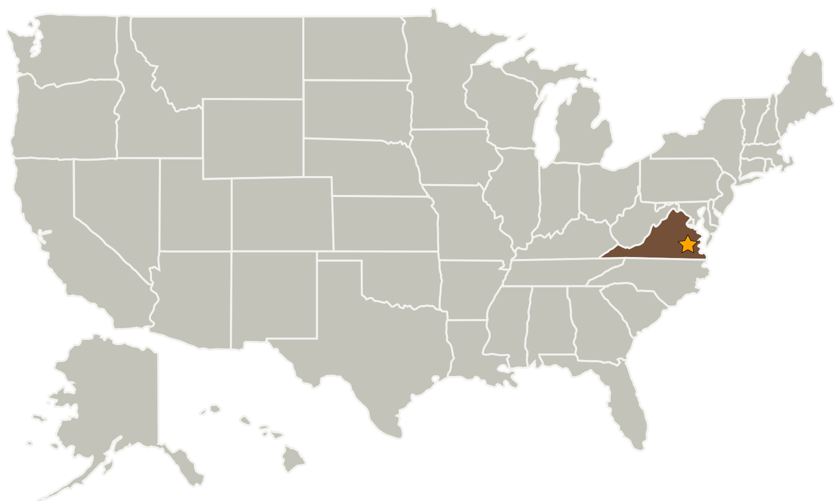
components become more vulnerable to particulate radiation (including neutrons, protons, and heavy ions) as their size shrinks and the operating voltage is reduced. Microelectronics in future aerospace vehicles and medical applications, such as pacemakers, require effective lightweight radiation shielding materials such as transparent or nontransparent hydrogenated BNNT composite coatings or layers. To our knowledge, no experimental or computational studies have been done on the radiation shielding properties of BN and BNNT containing polymers, except for our preliminary experimental study. The proposed research will provide a systematic assessment of the fundamental radiation shielding properties of the proposed materials (TRL = 1-2).

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Langley Research Center(LaRC)	Lead Organization	NASA Center	Hampton, Virginia
National Institute of Aerospace Associates	Supporting Organization	Industry	
Rochester Institute of Technology(RIT)	Supporting Organization	Academia	Rochester, New York

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Langley Research Center (LaRC)

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

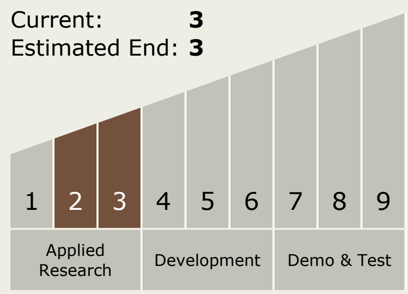
Eric A Eberly

Principal Investigator:

Sheila A Thibeault

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



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Primary U.S. Work Locations

Virginia

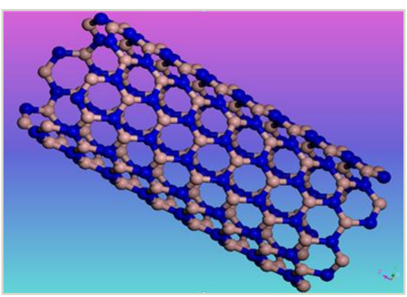
Project Transitions

September 2011: Project Start

September 2012: Closed out

Closeout Summary: During this NIAC Phase I study, we have accomplished th e following: -We have established, computationally, that hydrogen (H) containin g BN and BNNT materials (hereby named HBN materials) can outperform the sta te-of-the-art polyethylene with respect to radiation shielding. Since BNNT materi als are vastly superior with respect to mechanical and thermal properties, our H BN materials have the potential to be disruptive, multifunctional, structural radia tion shielding materials. This is a Revolutionary Breakthrough! -We have made a sizable supply of hexagonal boron nitride (h-BN) containing LaRC-SI polyimide n anocomposite films. We have begun characterizing these materials for structural materials properties and radiation shielding effectiveness. -We have developed a technical work plan using existing LaRC equipment for producing hydrogen cont aining BNNT (i.e., HBN). -We have developed a comprehensive computational, e xperimental, and systems analysis approach for proceeding on a pathway to flig ht. 2015 Patent #US 20150248941 A1 Radiation shielding materials containing hydrogen, boron and nitrogen and 2013 Patent # US20150248941 Radiation shi elding materials containing hydrogen, boron and nitrogen

Images



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Project Image Radiation Shielding Materials Containing Hydrogen, Boron, and Nitrogen: Systematic Computational and Experimental Study
(https://techport.nasa.gov/image/102054)

Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  - └ TX06.5 Radiation
    - └ TX06.5.3 Protection Systems

Target Destination

The Moon